4.1.5. OZONESONDES

Table 4.6 lists the CMDL ozonesonde sites for 2000-2001. Weekly ozonesondes were launched at eight sites, and daily ozonesondes were launched during three intensive campaigns, the Texas Air Quality Study (TexAQS), Total Ozone Measurements by Satellites, Sondes, and Spectrophotometers at Fairbanks (TOMS^{3}F), and Southern Great Plains/Cloud and Radiation Testbed (SGP/CART). SMO and Fiji missed several weeks due to supply shortages. A critical task of the ozonesonde project is the testing of ozonesonde performance at CMDL and in field and laboratory intercomparison projects. The Jülich Ozonesonde Intercomparison Experiment (JOSIE-2000) held at the Research Center in Jülich, Germany, in September 2000 provided the venue for one such intercomparison. Results are described in section 4.2.1.

All the sites and campaigns used electrochemical concentration cell (ECC) ozonesondes purchased from EN-SCI Corporation and Science Pump Corporation. The ozonesondes used a 2% potassium iodide sensing solution. CMDL average pump efficiencies were used to process the data [*Johnson et al*., 2002]. Pump efficiencies are determined in CMDL's environmental chamber by measuring ozonesonde flow rates at ambient pressures between 100 and 5 hPa with an oil bubble flowmeter. About 10-12 new ozonesondes per year are selected randomly for calibration in the environmental chamber to ensure that the average pump efficiency remains consistent.

Ozonesondes are sometimes found by hikers, farmers, etc., after the flight and returned to CMDL where they are cleaned and reconditioned, and the pump efficiency is measured. The sondes are then checked for accuracy against a UV calibrator at surface pressure before they are flown again. The Boulder site is the only location routinely using reconditioned ozonesondes. Despite the additional testing, the reconditioned ozonesondes show a relatively high failure rate above 20 km, where the measurements appear to be too low. In 2000 nearly 20% of the reconditioned ozonesonde flights showed this problem above 20 km. For comparison a typical failure rate at a site with new ozonesondes is about 3-10%.

In 2001 the failure rate for the reconditioned ozonesondes at Boulder was reduced to 13%. The decrease may be related to an additional cleaning procedure, started on May 1, 2001, that involves pressure flushing of the ion bridge between the cathode and anode cells of the ECC ozonesonde sensor with distilled water (1-m column head pressure). Prior to use of the flushing procedure, the sensor cells were only soaked for several days, filling up both the anode and cathode chamber with 5 mL of distilled water.

Overall, the successful Boulder ozonesonde flights compare very well with the Boulder Dobson spectrophotometer, measuring within 1.7 ± 4.4% when the constant mixing ratio extrapolation method is used to compute the residual ozone above the burst altitude of the balloon, and −1.6 ± 3.6% when the solar backscatter ultraviolet (SBUV) residual tables from *McPeters et al*. [1997] are used.

Since 1986 the ozonesondes flown at SPO have provided a detailed look at the yearly ozone hole development. Balloonborne ozonesondes are launched once per week throughout the year, but the frequency is increased to two or more per week once the first signs of ozone depletion appear in late August, and then to every other day as the ozone hole minimum approaches. Figure 4.6 shows the typical pre-ozone-hole profiles during the winter compared with the minimum total column ozone observed in late September. The main ozone depletion layer at 14-21 km continues to show near-complete ozone destruction each year. Years 2000 (Figure 4.6a) and 2001 (Figure 4.6b)

TABLE 4.6. Summary of 2000-2001 Ozonesonde Sites, Projects, and Total Number of Sondes

	2000		2001		
Ozonesonde Sites	Totals	Dates	Totals	Dates	Project
			Station (weekly)		
Boulder, Colorado	60	Full year	51	Full year	NOAA long term
MLO	46	Full year	61	Full year	NOAA long term
SPO	68	Full year	71	Full year	NOAA long term
Fiji	34	Full year	36	Full year	PEM Tropics/SHADOZ
SMO	43	Full year	35	Full year	PEM Tropics/SHADOZ
Trinidad Head, California	47	Full year	44	Full year	NOAA "Health of the Atmosphere"
Huntsville, Alabama	52	Full year	47	Full year	NOAA "Health of the Atmosphere"
Galapagos	50	Full year	50	Full year	SOWER/SHADOZ
			Intensives (~daily)		
Houston, Texas	27	Aug. 18-Sept. 14			TexAQS 2000
Fairbanks, Alaska			30	March 20-April 25	TOMS^{3}F
Lamont, Oklahoma			7	Aug. 27-Sept. 1	SGP/CART

PEM Tropics, Pacific Exploratory Mission in the Tropics; SHADOZ, Southern Hemisphere Additional Ozonesondes; SOWER, Soundings of Ozone and Water in the Equatorial Region.

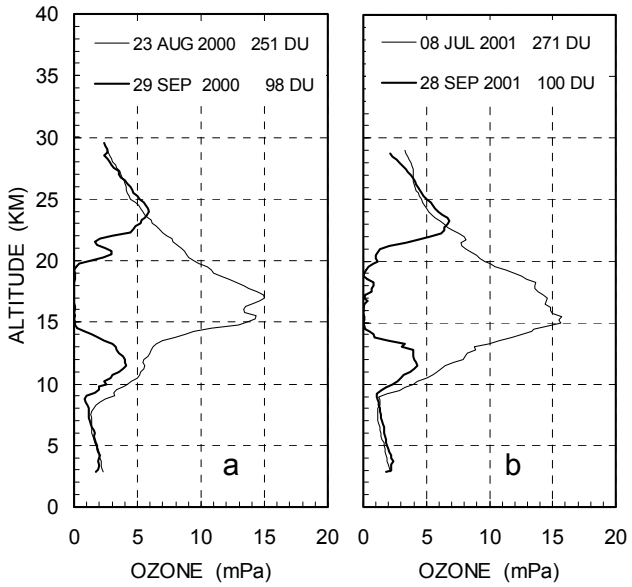

Fig. 4.6. SPO ozonesonde profiles measured in (a) 2000 and (b) 2001 showing the pre-ozone-hole profiles in austral winter and the minimum total column ozone profiles in late September. Total column ozone values (DU) are given for the dates shown.

were similar in total column ozone minimums: 98 ± 4 DU on September 29 and 100 ± 4 DU on September 28, respectively. These minimums were about 7-10 days earlier than the average minimum date observed at SPO. The recovery, however, occurred much sooner in 2000 than in 2001 because in 2000 the polar vortex deteriorated and shifted away from South Pole. Total column ozone was already at 259 DU on November 3, 2000, but did not exceed 220 DU until December 8, 2001 (Figure 4.7).

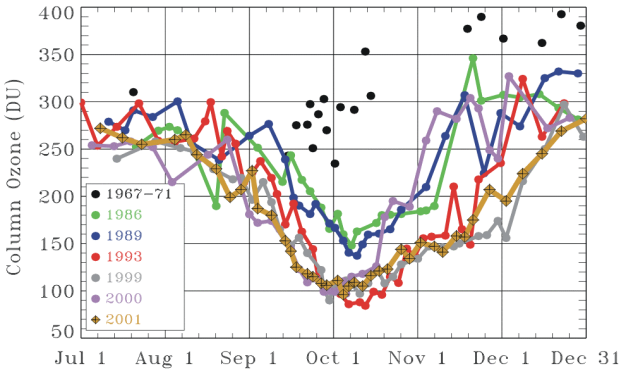

Fig. 4.7. SPO total column ozone (DU) measured by ozonesondes during the development and recovery time period of the Antarctic ozone hole. The 1967-1971 measurements were made prior to the existence of the yearly ozone hole.

Twenty-seven ozonesondes were flown at Houston, Texas, from August 18 to September 14, 2000, during the TexAQS 2000 field program. The project included several groups measuring gaseous and particulate air pollutants from ground instruments and aircraft platforms. The ozonesondes were launched every afternoon at 1500 local time during the campaign. Figure 4.8 shows the average ozonesonde profiles (and 1 standard deviation bars) measured during the late-summer project in Houston. The highest surface ozone mixing ratio measured by the ozonesondes during the 4-wk period was 113 ppbv on August 31, 2000. Total ozone averaged 291 ± 12 DU, which differed by −1.0 ± 3% from the NASA Total Ozone Mapping Spectrometer (TOMS) total ozone measurements.

Seven ozonesondes were launched from the U.S. SGP/CART site near Lamont, Oklahoma, during an intensive measurement campaign from August 27 to September 1, 2001. Total ozone remained very steady during the week at 302 ± 4 DU measured by the ozonesondes. For comparison, TOMS measured 297 ± 6 DU.

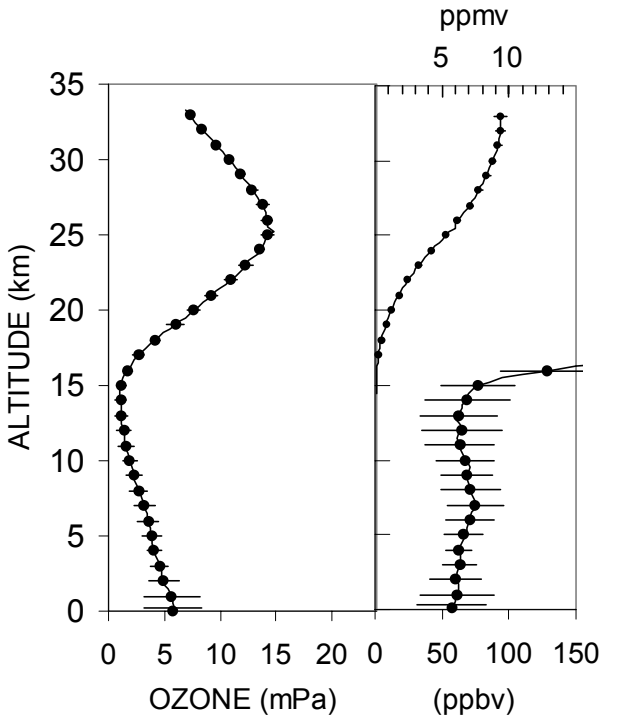

Fig. 4.8. Average of 27 ozone partial pressure (left panel) and ozone mixing ratio (right panel) profiles measured during the Houston (TexAQS-2000) campaign. The error bars represent 1 standard deviation.